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NRL Memorandum Report 1659

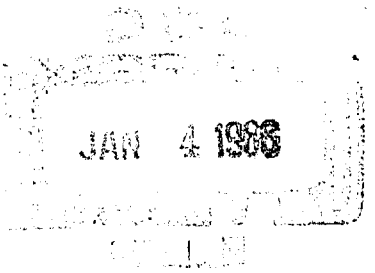
Evaluation of an Experimental "Swallow-Tail" Towing Technique Aboard USNS MIZAR

[Unclassified Title]

B. J. CULVERHOUSE

Techniques Branch
Sound Division

November 1965



U.S. NAVAL RESEARCH LABORATORY
Washington, D.C.

CONFIDENTIAL

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ABSTRACT

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The need has developed for a reliable paravane towing technique for use by surface ships in connection with an Acoustic Torpedo Countermeasure Investigation. The problem was to evaluate two independent "Swallow-Tail" towing techniques and determine their ability to provide a stable platform on which to mount acoustic torpedo countermeasure equipment. Two such paravanes were tested on the USNS MIZAR (T-AGOR-11) enroute from Bermuda in May 1965. The Boeing Company, Vertol Division, and the Braincon Corporation paravanes were individually designed and tested. The Vertol paravane exceeded the performance specifications of 8 knots, 30 degrees span angle and met the towing duration specification of 50 hours without adjustment. The Braincon paravane was able to tow at 8 knots but was unable to achieve the required span angle and towing duration. A comparison of data taken at sea on the two units indicated Vertol's technique to be very suitable to the above-mentioned application. However, the Braincon technique cannot be recommended at this time.

PROBLEM STATUS

This is an interim report on the problem. Work on the problem is continuing.

AUTHORIZATION

NRL Problem 55S01-22

BUSHIPS Project SF011-03-02-2375

EVALUATION OF AN EXPERIMENTAL "SWALLOW-TAIL" TOWING TECHNIQUE ABOARD USNS MIZAR

(Unclassified Title)

INTRODUCTION

The Braincon Corp. of Marion, Massachusetts and the Vertol Division of Boeing Company of Morton, Pennsylvania were awarded contracts to develop equipment suitable for side-angle towing configurations at speeds of from 8 to 12 knots and depths of 30 to 75 ft with minimum span angles of 30 degrees from center line of ship to one tow. Both companies were given identical specifications to which the equipment must perform.

This experiment attempts to evaluate the "Swallow-Tail" tow techniques which could be used for improved acoustic-torpedo countermeasures defense of surface vessels. The tactical advantages and disadvantages of this technique will be discussed in a future report. This report will discuss only the mechanical and hydrodynamics equipment characteristics, with special regard given to performance and reliability.

EQUIPMENT

The towing operations and testing were conducted using the USNS MIZAR (T-AGOR-11) as a towing vessel enroute from the US Naval Station Bermuda, to the US Naval Shipyard, Philadelphia. The MIZAR, which has a light displacement of 2,035 long tons and is capable of speeds up to twelve knots, was considered adequate for these tests; however, it is hoped that some high-speed tests up to 25 knots will be conducted in the near future. The MIZAR stern-deck area was fitted with an electric double drum T-Mark 6 streaming winch, 5 hp (Fig. 1), which was very suitable for launching, towing, and retrieving the two towing systems independently of one another. Necessary fairleading, shackles, dynamometers, weldments, etc. were also installed, so that the two systems could be towed simultaneously without interference from the other.

The Braincon system (Fig. 2a, 2b) uses a support surface vehicle with a 35-ft towing cable attached. This unit controls the depth of the two lower units, which are both V-fins. The type 328 upper V-fin acts as a paravane that supplies the outward force, while the lower type 327 V-fin acts as a depressor and supplies the downward force. Each V-fin is equipped with two small aileron trim tabs, located on the trailing edges of the wings.

These tabs are factory set at 30 degrees for optimum performance. The type 327 V-fin is also equipped with a vertical stabilizer (adjustable rudder) to aid the paravane in obtaining the optimum lift. All Braincon units are constructed of a Fiberglas laminate for strength and resistance to salt-water corrosion. Both V-fins are connected to the towing cable with swivel joints, to allow free movement in the water. The type 328 V-fin is installed with a 3/4-in. stainless stop bolt to prevent rotation of the unit when launching. The section of tow cable between the surface vehicle and the type 328 paravane is supplied with "haired fairing" to minimize drag and vibration. A stainless 3/4-in. rod (spacing bar) connects the two V-fins and maintains a constant separation between the two. To change the system from port to starboard towing, the type 328 V-fin must be removed and mounted on the opposite side of the swivel fitting.

The Vertol system (Fig 3a, 3b, and 3c) consists of a Fiberglas marker float and a single all-metal paravane (otter) with a 3.6 ft^2 wing area. The marker float serves two functions. One function is to aid the paravane in maintaining constant depth and stability, the other to serve as a reference point when taking span-angle measurements. The paravane unit, which acts as an otter, supplies both outward force and downward force. The stabilizer is adjustable from 3 to 7 degrees and maintains longitudinal stability. This adjustment increases or reduces span angle as required. In these tests the stabilizer was set at 5.6 degrees, giving the paravane an 11-degree angle with the normal to the surface. The paravane also has an adjustable tow fitting that allows control of the downward force. This is adjustable from zero to plus or minus four degrees. The weight shown on the wing tip is used as a ballast and must be changed when rigging from port to starboard towing.

Figure 4 shows a plan view of the towing configuration that was used on the MIZAR, with Vertol on the port side and Braincon towing from the starboard side.

The performance specifications as set forth in the contracts as shown in Table 1, listing minimum requirements as well as target specifications on a best-effort basis. The tests began with the minimum and proceeded toward the maximum with regard to time limitations. Contractor engineers made all adjustments to their own equipment.

Table 1

Performance Specifications

Characteristic	Performance Required	Target
Speed (knots)	8	15
Distance Astern (aft. extension) (ft)	300	600
Paravane Angle (span angle) from center line ship to one tow (degrees)	30	60
Paravane Depth (ft)	25	75
Cable Tension (not to exceed) (lb)	2500	2000
Maximum Sea State	3	4
Tow Duration (without failure) (hr)	50	200

OPERATIONS

The towing operations were scheduled on a 24-hr basis; however, it was impossible to make span-angle measurements at night. Span angles were measured with a 180-degree protractor fitted with sights, and mounted on a tripod (Fig. 5). All span-angle measurements were made using the forward point of the support floats as a reference mark. A corrected figure allowing for additional span angle for each system will be shown in Table 2. A regular watch was set up on an hourly basis for the purpose of obtaining the following data:

1. Date and time
2. Speed and course
3. Sea state
4. Wind and sea direction
5. Tow angle
6. Cable tension
7. Cable length

This information was recorded on an hourly basis by the Senior Scientist on board for both systems throughout the entire towing operation.

The following sections give a day-by-day account of the towing tests as performed at sea. Table 2 lists the results of both systems for comparison.

11 May, 1965

The USNS MIZAR left Bermuda at 1300 hr and steamed until 1545 hr, at which time the ship was slowed for launching both paravane systems. The sea state was between 0 and 1, with swells of about 5 ft. Both systems were launched at 1600 hr. The ships speed was increased slowly to 8 knots, and both tow cables were streamed to 300 ft. Both systems were at approximately 35 ft in depth. Braincon was using a hair-faired cable. At 8 knots the Braincon paravane angle to the ship's centerline was 24 degrees, and the cable tension varied from 200 to 250 lb. The Vertol system span angle measured 30 degrees, and the cable tension was 650 lb. The testing continued until 1700 hr, when the cable on the vertol system pulled free from the torque grip. The ship was turned to retrieve the float and paravane. A new cable torque grip was installed, and the testing continued as before at 8 knots until 1845 hr, when both cables were extended aft to 500 ft at 8 knots. The Braincon system measured 14 degrees span angle, while the tension increased to 375 lb. The Vertol gear measured 27 degrees span angle with cable tension at 800 lb. Sea state at this time was still between 0 and 1, with 5 - ft swells. At 1930 hr both tow cables were retrieved to an aft extension of 300 ft, and speed was between 7.5 and 8 knots. The Braincon system measured 24 degrees and 375 lb tension. The Vertol system was streaming at an angle of 33 degrees, and the tension was recorded at 750 lb. Both systems were towed during the night with this configuration. The sea during the night was state 2, with a gradual buildup to state 3 by morning. The dynamometer that was attached to the Braincon system slipped off of the line during the night. The last tension reading was at 0200 hr, with no significant change on either system.

12 May, 1965

At 0700 hr both tows were observed, and the readings were as follows.

Braincon span angle was 22 degrees with 350 lb tension, and Vertol was 32 degrees and 750 lb tension, speed 8 knots. At 0730 hr towing was suspended while the ship made repairs. During this period adjustments were made to the Braincon equipment. The vertical stabilizer was moved 3/64 in. to port. The surface-float tow point was moved forward one set of bolt holes. This change was to stabilize the float action on the rough seas. The Vertol system was changed so that the marker float was moved to a point 35 ft forward of the otter and attached to the main tow cable with a 2 - ft length of cable. This method of towing will be referred to as type 2 towing configuration, the previous being type 1. The marker-float stabilizer was also adjusted to keep the float nose down during heavy seas. At 1000 hr both systems were relaunched, speed 8 to 10 knots, with a 300-ft-aft extension and a towing depth of 35 ft. The Braincon gear measured 18 to 20 degrees span angle with 300-lb tension, and the Vertol span angle measured 43 degrees with 800-lb tension. The sea state at this time was 3, with 14-knot winds and 6-ft swells. During this launching it was noted that the Braincon gear had a fouled cable, necessitating retrieval and relaunching. At 1200 hr the Vertol system again pulled free from the cable torque grip. This time the otter was lost, since the float was no longer attached to the otter with 35 ft of cable, as in type 1. During the afternoon Braincon continued to tow with a 24 to 26 degree angle at 8 knots. At 1600 hr the Vertol system was again launched, using the type 1 towing configuration. It was decided not to use the cable torque grip to fasten the paravane to the towing cable. Instead the towing cable was looped through the tow fitting, and cable clamps were used. The span angle measured 34 degrees, with 800 lb tension. At this time the Braincon gear was brought in and the vertical stabilizer was adjusted another 1/32 in. Both systems towed throughout the night with a state 2 to 3 sea and winds 7 to 14 knots with 5 to 7 ft swells.

13 May, 1965

Both units were towed during the day with no mishaps. An inspection was carried out at 1100 hr, and there was no evidence of fatigue on either system. They were both relaunched. A speed of 8 knots was maintained throughout the day. Braincon's span angle was between 22 and 24 degrees with tension 300 lb. The Vertol system measured 30 to 35 degrees, with a

tension reading of 850 lb. The seas were at state 2 and building with 6 to 15 knots of wind. The ship made turns of 180 degrees twice during the remainder of the day, with no apparent effect on the towing systems.

14 May, 1965

At 0600 hr both systems were observed to be in tow. Speed was between 7.5 and 8 knots. The sea state was approximately 3, and the winds had increased to 18 knots. The span angle and tension readings were again taken every hour, with Braincon readings ranging 20 to 28 degrees and 300 to 350 lb tension. The Vertol system was consistently reading above 30 degrees, with readings of 31 to 35 degrees span angle with the tension at about 800 lb. At 1000 hr the MIZAR made course changes to allow the tows to be subjected to wind and seas from various directions. During this period the readings remained about the same as earlier in the day, with Braincon measuring 23 degrees and Vertol 35 degrees. Ship speed during the period of from 1000 hr until 1200 hr was 12.0 knots (maximum speed). The weather then turned for the worse, with winds at 20 to 25 knots and a sea state of 5. The swells were 10 ft in height. The tests were continued until 1500 hr when the Braincon system paravanes came to the surface and began to gyrate in the water. It was then decided to retrieve the Braincon system and examine the cable and paravanes. It was noted that the hair-faired cable was badly twisted and unusable. The V-fins were not damaged, but the paravane spacing bar (Fig. 6) was bent 15 degrees out of normal, making it unusable. Braincon tests were suspended for the rest of the day. It must be noted that the Braincon system had towed for 49 hours without any failure or adjustment. The Vertol system continued to tow until 1800 hr, when it was decided to suspend all towing operations due to weather and sea conditions. The Vertol system had towed for 50 hr without failure or adjustment.

15 May, 1965

The weather conditions had improved to the point where the towing operations could be continued. The sea state was between 1 and 2, with winds of only 10 knots. Ship speed was 11 knots. Vertol equipment was relaunched with no adjustments or changes. Towing type 1 was still being used. The Vertol span angle was 32 degrees, with 1200 lb tension.

The aft extension was still 300 ft. Braincon was out of the water, with repairs being made. A new paravane spacing bar had to be installed, and also a new lower tow cable had to be installed between the surface vehicle and the V-fin. A 75-ft hair-faired cable was used, since the first cable was unusable. At 1000 hr the Vertol otter definitely struck a large object under the surface, causing the cable connection to sever just above the cable grips. Cable tension reached 3400 lb momentarily. The units were recovered, however, and it was noted that a large amount of dark gray jelly-like matter was found on the entire leading edge of the otter wing. A sample of this matter was mounted on a glass slide and refrigerated for bioanalysis. A later analysis showed the sample to be from that of a large mammal, of the whale family. The Vertol equipment was changed for the type 3 towing configuration. This type involved the otter only, suspended directly on the towing cable. The depth was controlled by the otter trim only, since no float was used. The unit was relaunched immediately, and the span angle with 300 ft of aft extension was calculated to be 45 to 49 degrees at 8 knots. The tension however was 475 lb, much less than with types 1 and 2 towing. The ship speed was increased to 12 knots and the span angle was 39 degrees, but the tension increased to 1400 lb. This was due to otter trim, since the otter was now at a depth of 45 to 55 ft. The type 3 towing was the most easily handled during launching and retrieving operations.

At 1230 hr the otter pulled free from the tow fitting and was lost. This was the second and last otter on board, so the Vertol operations were discontinued. The sea state at this time was 2. At 1300 hr the Braincon system was ready for relaunching. An aft extension of 300 ft was used. This ship speed at this time was 8 knots. The span angle was measured at 21 degrees and tension was 350 to 400 lb. The towing (Fig. 7) was continued at this speed until 1500 hr, when it was increased to 11 knots. At this time the aft extension was lengthened to 600 ft. Shortly thereafter the Braincon V-fins began to gyrate again, causing the support vehicle to tumble through the water. The system was retrieved and inspected. The 75-ft faired cable was found to be twisted, and several strands of the shielding that holds the fairing in place was broken. The electrical cable itself was found to be unserviceable. The paravane spacing bar (a new replacement) was bent in the

same manner as previously described. Towing operations were then suspended for the rest of the day, for the purpose of making repairs and refitting the Braincon system.

16 May, 1965

The V-fin system was launched again at 0900 hr with 35 ft of unfaired cable from the V-fins to the support vehicle. The tow length was 300 ft. Speed at this time was 8 knots. The sea was approximately state 2. Ten series of 30-degree-rudder turns were made. The system appeared to have no problems during this phase of the tests. The speed was increased to 11 knots. The same 30-degree turns were again made to port and starboard. During these turns the V-fins tended to kite to just under the surface (2 to 3 ft) with the 300-ft aft extension. The V-fins, however, did not enter the area of the wake, but remained about 8 to 10 ft to starboard. The tow cable length was increased to 500 ft, with a speed of 11 to 12 knots. Under these conditions the Braincon system performed more effectively. The V-fins and support float crossed the wake during the hard turns to port so that the tendency to kite was eliminated. The tests continued for several hours with a series of figure-eight turns at high speeds. No further difficulty was experienced. Tests were concluded at 1600 hr May 16.

RESULTS

This portion of the report will be devoted to an analysis and comparison of the two systems. Table 2 shows the different modes of towing with regard to performance specifications.

Upon comparison of the two systems described in Table 1, it is readily evident that the Boeing/Vertol system obtained a much greater span angle, in all modes of towing, than did the Braincon system. It must also be mentioned that the Vertol equipment was considerably easier to launch and retrieve in all types of weather and seas. The Braincon gear had a tendency to foul in the towing cable while launching.

The Vertol gear was launched by merely throwing the float and otter over the side, while the Braincon system had to be lowered by hand slowly over the side. The cable tension recorded was greater with the Vertol system, but well within the limitations of the performance specifications. Both systems were towed for about the same duration, with both systems experiencing some difficulty. The main problem Braincon had was the instability of the V-fin at speeds exceeding 10 knots, with an aft extension shorter than the turn radius of the tow ship (300 ft). With this configuration the V-fins were unstable on port turns. However when the aft extension was increased to 500 ft the problem was nonexistent. The only problem encountered by Vertol was the cable torque grips. It was discovered after the trip that the torque grips may have been installed improperly on the cable, thus allowing the cable to pull free several times. This was by no means a fault in the Vertol system.

Braincon had no hardware failures during the trip with the exception of the bend in the paravane spacing bar. The system proved to be quite durable, even during periods of high sea states. It was towed for 49 hours without adjustment, which was one hour short of the minimum specification.

CONCLUSIONS

The tactical advantages and disadvantages of using the "Swallow-Tail" tow technique to defend surface vessels against acoustic torpedo attack will be discussed in a future report. The following conclusions refer only to the mechanical and hydrodynamic aspects of this problem.

1. The Vertol system met the minimum required towing time of 50 hr, and performance exceeded the minimum specifications in three different towing modes, making it very versatile from a standpoint of housing electronic packaging for countermeasures.

2. The type 3 tow configuration used by Vertol is considered to be the most economical as well as the most efficient.

3. The performance of the Vertol system is independent of the sea

condition and can be used to reach substantial depths and still maintain the required span angle.

4. The stability of the Vertol paravane has been found to be very suitable, and should be given consideration in future applications of this type.

5. Certain simple modifications would have to be made to the Vertol paravane and system in order to make it suitable for housing an acoustic source.

6. The Braincon system towed for a period of 49 hours without adjustments. Performance was acceptable with the exception of span angle, which was in some cases much less than the minimum required.

7. It was found that the Braincon system did experience less cable vibration due to the haired fairing.

8. The stability of the Braincon paravane was not as desirable due to the instability during certain turning maneuvers.

9. The Braincon type 327 V-fin, however, does have a suitable mounting area for an acoustic source, and no modifications would have to be made.

10. The determination of a suitable towing system is completed; however, modifications must be made to the Vertol paravane to house the electronics apparatus itself, and work in this area is continuing.

ACKNOWLEDGMENTS

Acknowledgment is given to Messrs Norman H. Dale and Lewis G. Galli of the Sound Division for their technical support and cooperation on this project. Acknowledgment should also be given to Capt R. E. Salman and crew of the USNS MIZAR, Mr. Robert Sundblad, of Braincon and Mr. Steve Grzeszczyk of Vertol for their combined efforts and contributions, that made the sea trials possible.

Table 2
USNS MIZAR Towing Tests
DATA COMPARISON TABLE

	Type of Tow*	Ship Speed (knots)	Sea State	Cable Aft Ext. (ft)	Maximum Cable Tension (lb)	Maximum Span Angle (deg)	Towing Duration (hr)†	Total Tow Duration (hr)
Braincon Corp.	1	8	1-5	300	375	28	49	76
				500		14		
		10	3	300	350	20		
		12	2	300	375	23		
	2	8-11	2	300	400	21	2.5	2.5
Boeing/ Vertol Div.	1	8	1-5	300	800	35	50	68.5
				500		27		
		11		300	1200	32		
		12	3	300	800	35		
	2	10	3	300	800	43	1	2
	3	8	2	200‡	475	47	2.5	2.5
		12			1400	39		

*Braincon - Type 1 - 35 ft cable depth
Type 2 - 75 ft cable depth

Vertol - Type 1 - Marker float attached from otter on 35 ft cable
Type 2 - Marker float attached to tow cable 35 ft forward of otter on 2 ft cable
Type 3 - No float used otter only, depth 50 ft

†Duration of towing without adjustment to paravanes
‡300 ft of tow cable payed out, but due to extreme catenary an aft Extension of 200 ft was attained

Fig. 1 - T-MK 6 streaming winch

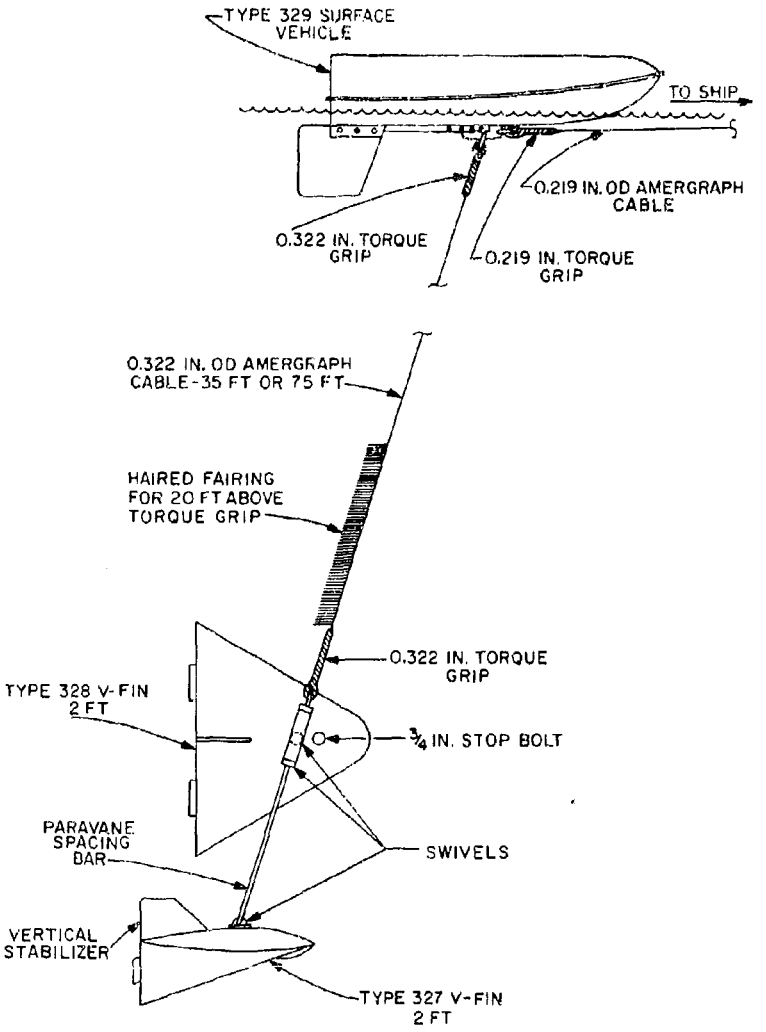

Fig. 2a - Braincon type 296 paravane towing system (port side configuration)

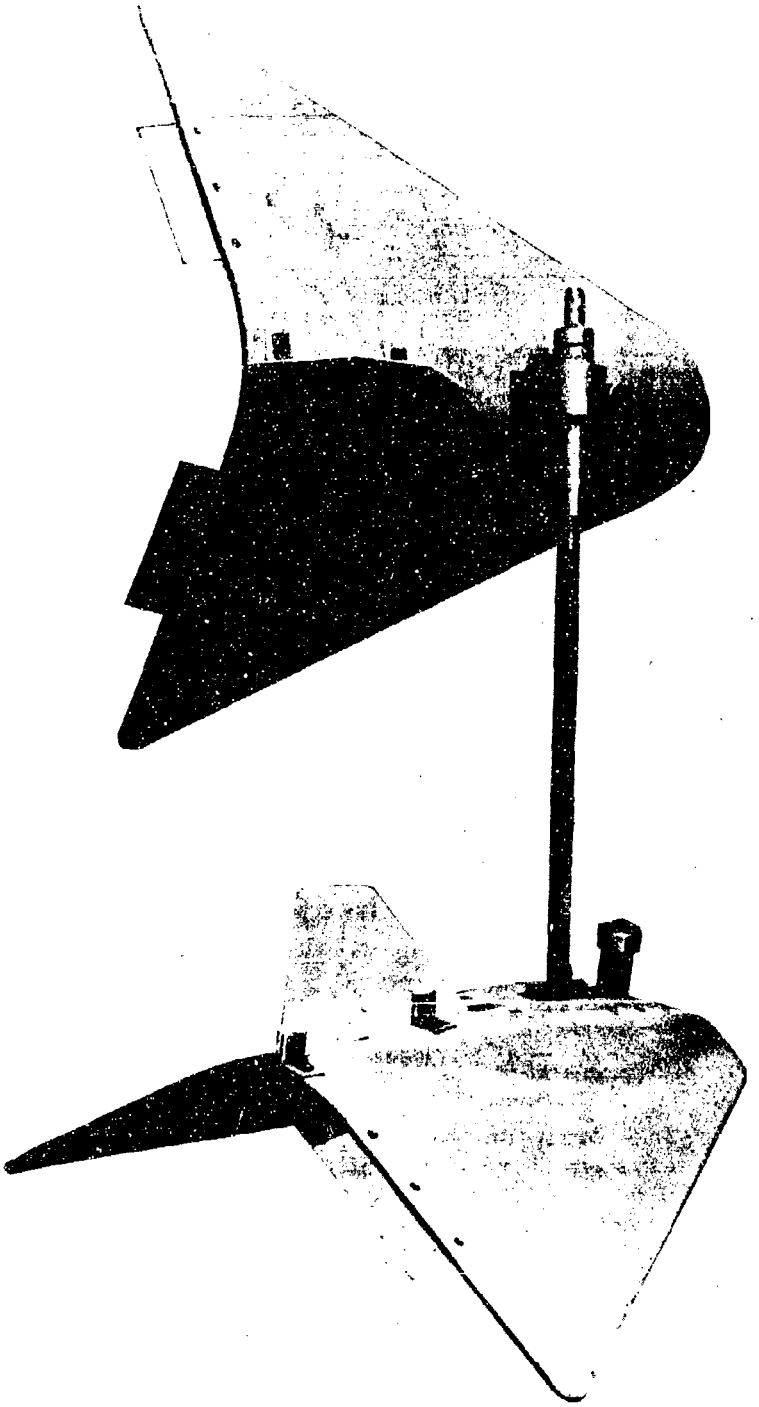

Fig. 2b - Braincon 327 and 328 paravanes

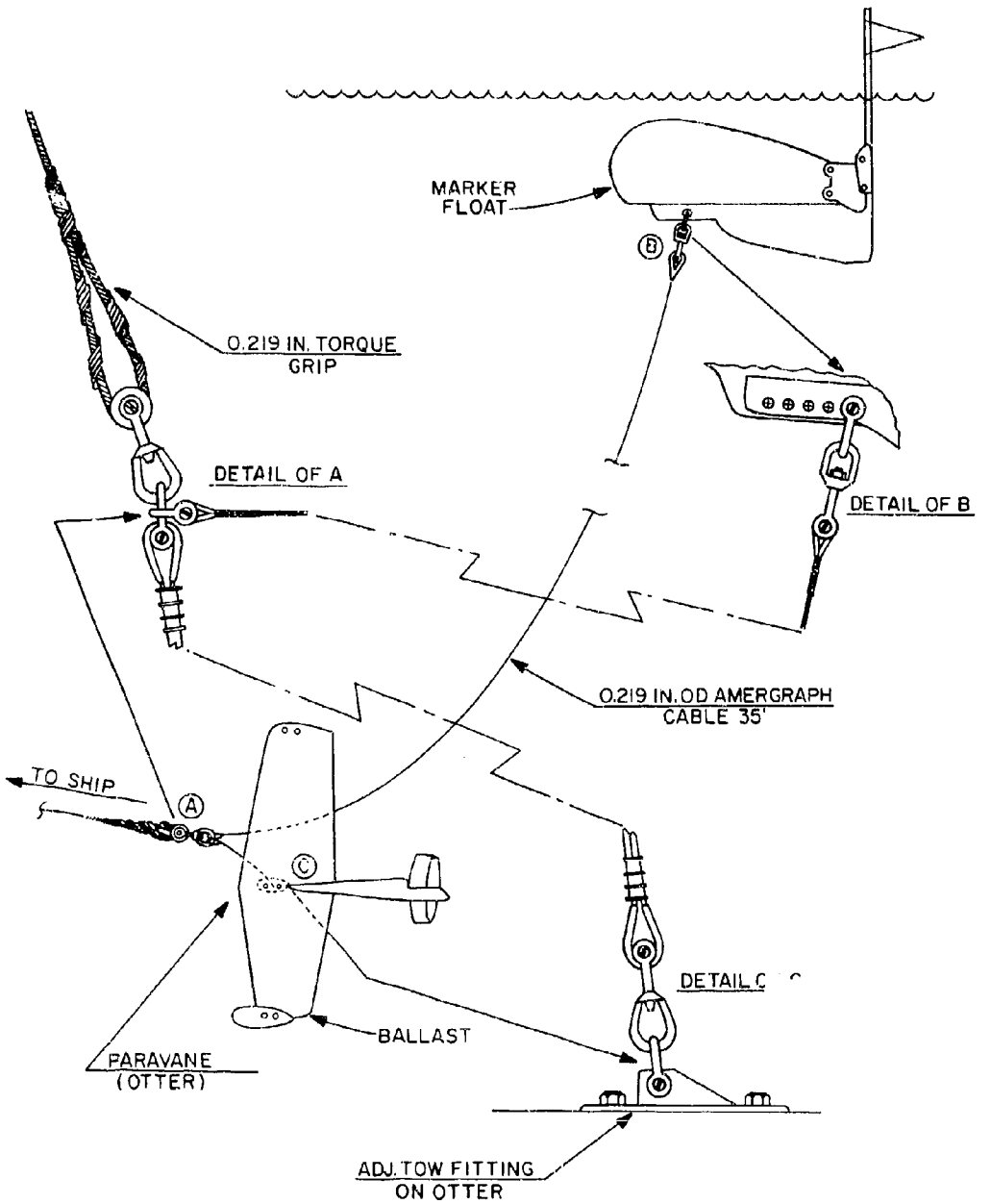

Fig. 3a - Boeing/Vertol paravane towing system
(port side configuration)

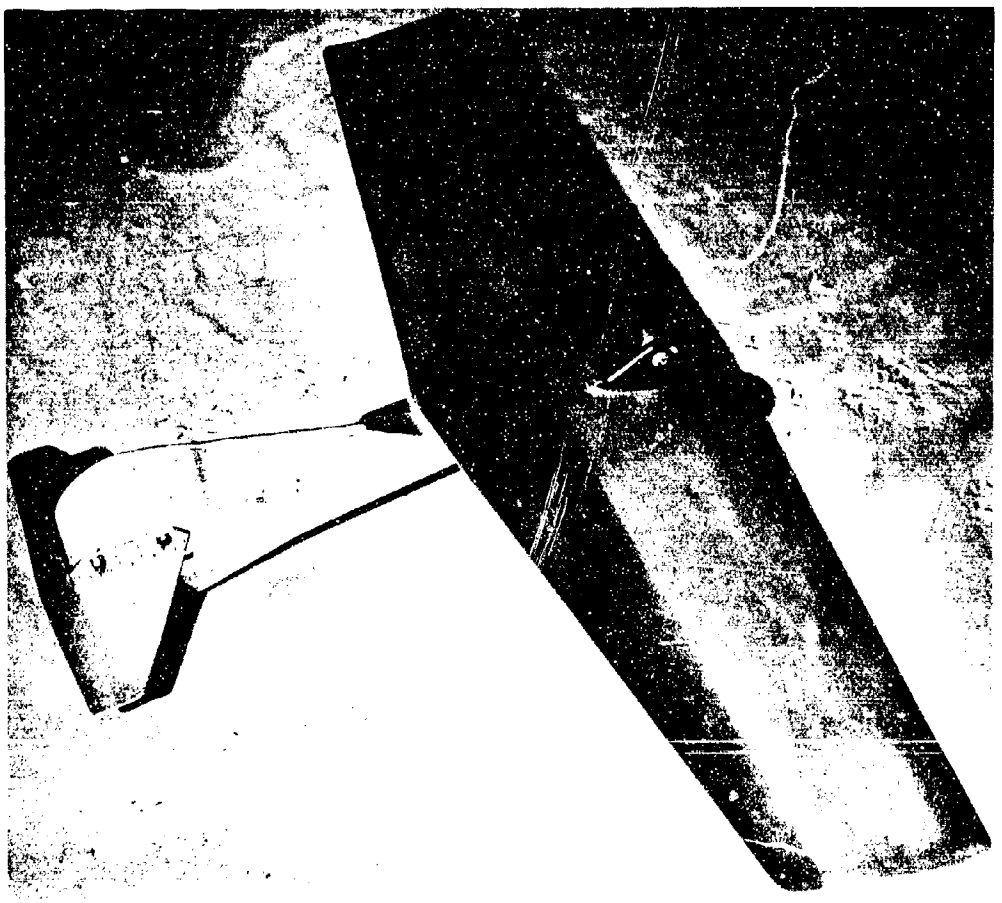

Fig. 3b - Vertol paravane unit (Ballast shown in central position)

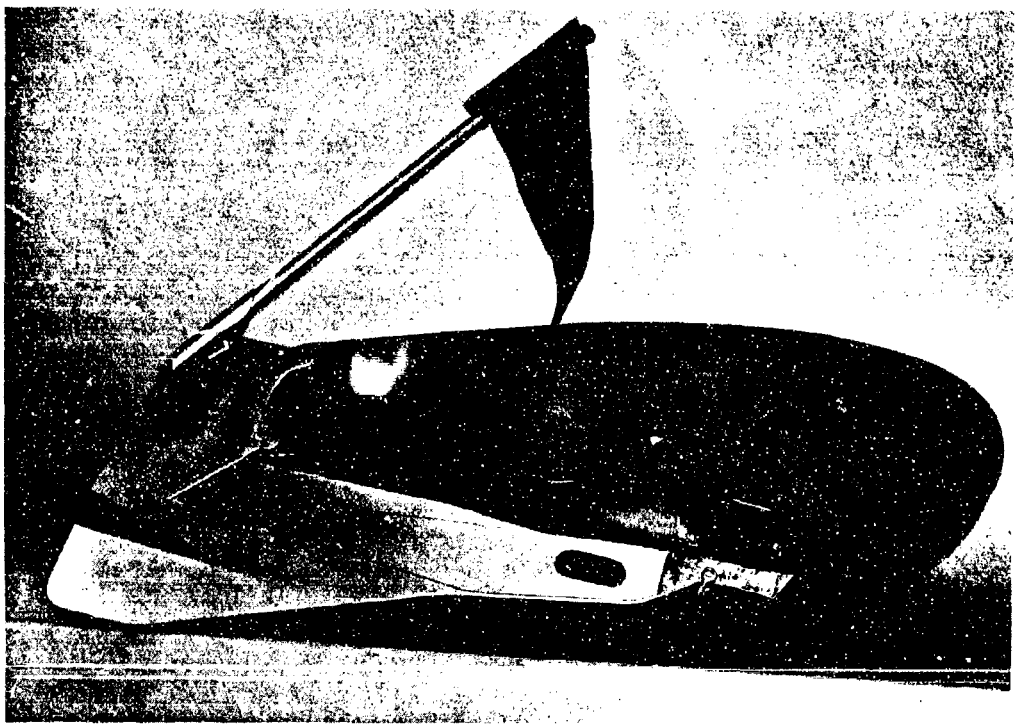

Fig. 3c - Vertol marker float

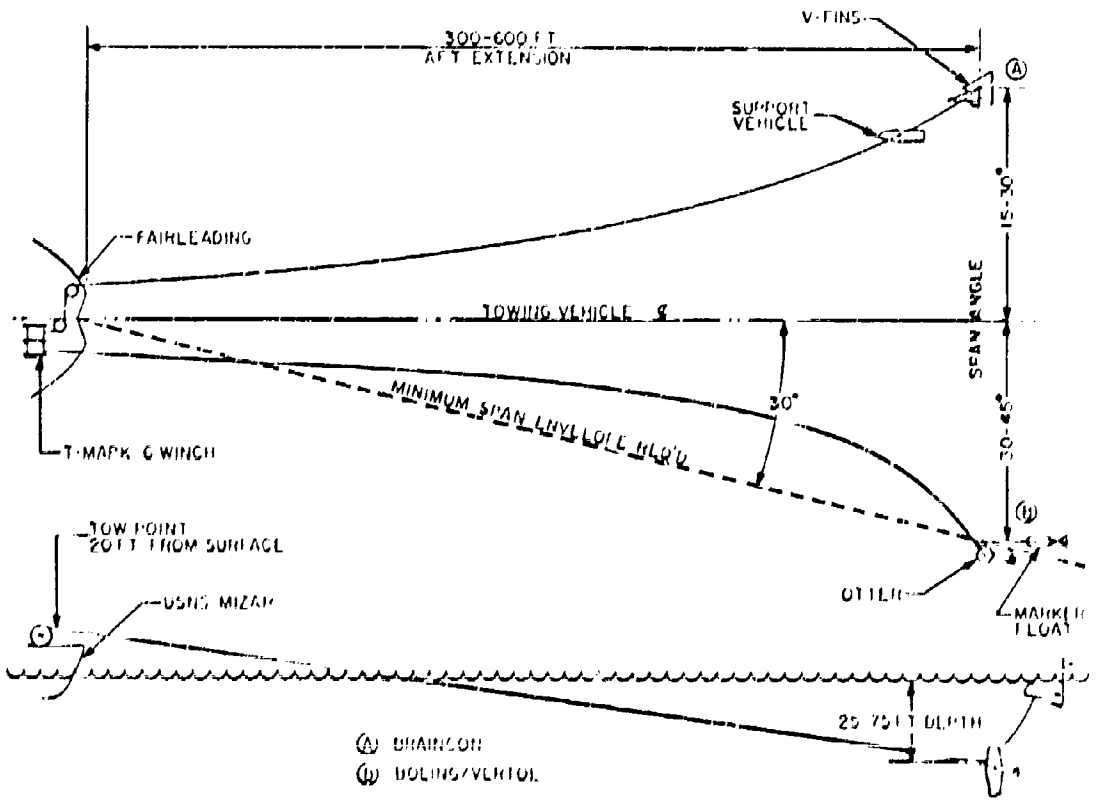

Fig. 4 - Plan view of towing configuration

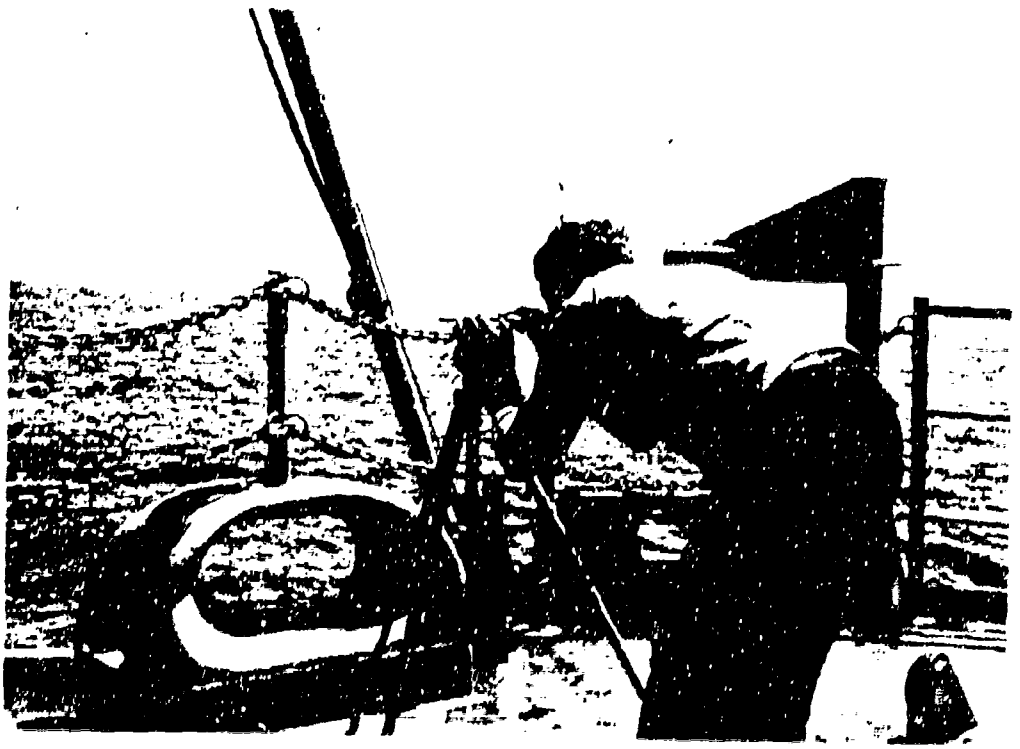

Fig. 5 - Span angle measurements being taken on the stern of the MIZAR

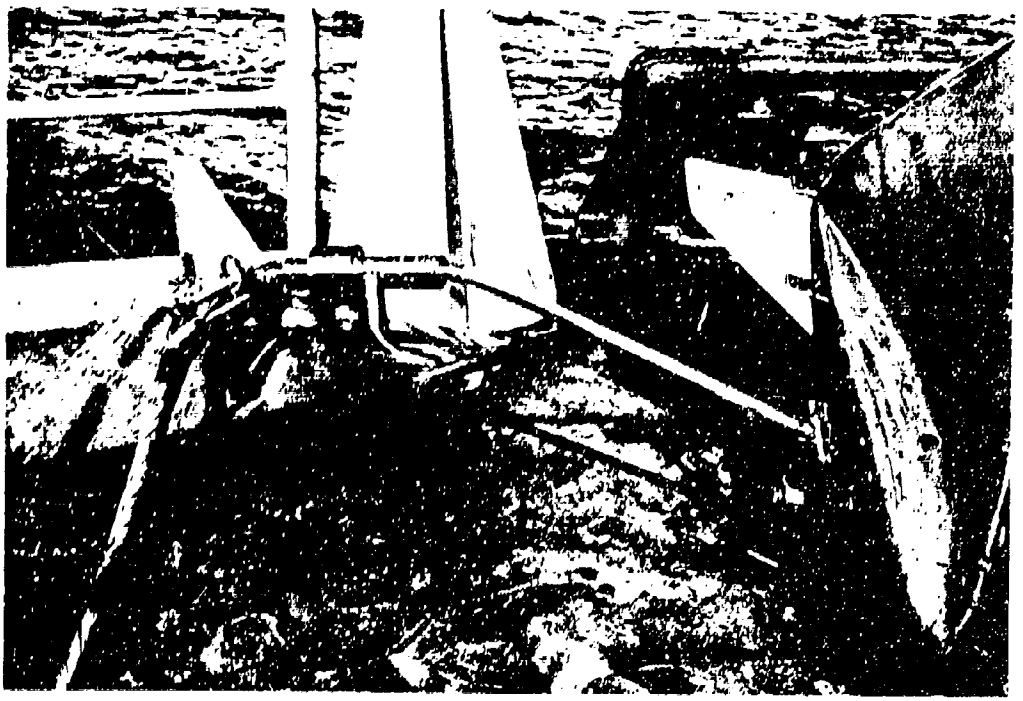

Fig. 6 - Damaged Braincon paravane spacing bar

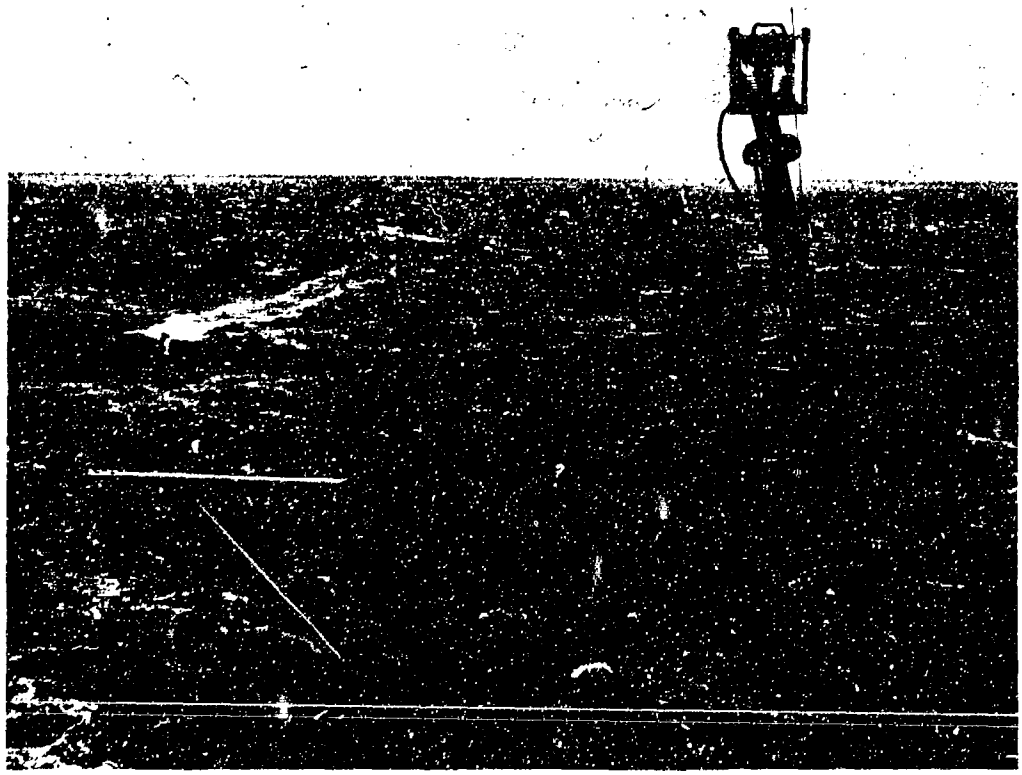

Fig. 7 - Typical towing view of paravane span angle

UNITED STATES GOVERNMENT

Memorandum

7100-094

DATE: 10 September 2003

REPLY TO ATTN OF: Burton G. Hurdle (Code 7103)

SUBJECT: REVIEW OF REF (A) FOR DECLASSIFICATION

TO: Code 1221.1

REF: (a) "Evaluation of an Experimental "Swallow-Tail" Towing Technique Aboard USNS MIZAR" (U), B.J. Culverhouse, Sound Division, NRL Memo Report 1659, November 1965 (C)

1. Reference (a) describes the conduct of tests on two competing paravane towing systems. The tests were conducted aboard USNS MIZAR in May 1965. Tests showed the Vertol system to be the best.

2. The technology and equipment of reference (a) have long been superseded. The current value of these papers is historical.

3. Based on the above, it is recommended that reference (a) be declassified and released with no restrictions.

Burton G. Hurdle

BURTON G. HURDLE
NRL Code 7103

CONCUR: Edward R Franchi 9/11/2003

E.R. Franchi Date
Superintendent, Acoustics Division

CONCUR: Tina Smallwood 9/15/03

Tina Smallwood Date
NRL Code 1221.1